ELECTROSTATIC CHUCK

Patent number: JP10080168
Publication date: 1998-03-24
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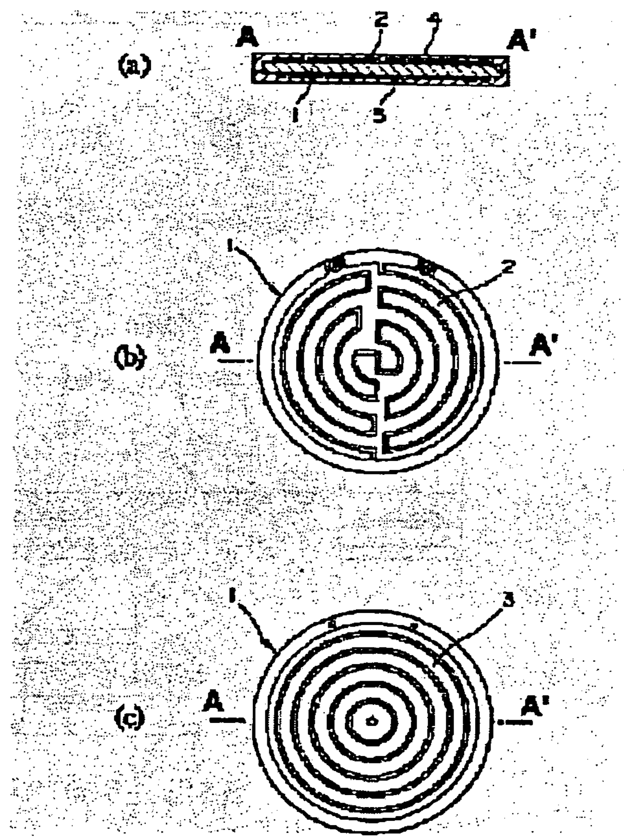
Classification:
- international: H02N13/00
- european:
Application number: JP19960250948 19960902
Priority number(s):

Abstract of **JP10080168**

PROBLEM TO BE SOLVED: To provide an electrostatic chuck which can restrain a warpage from being generated in its manufacture even when a support substrate is thin and compact by a method in which an electrostatic chuck pattern is formed on the surface of the substrate and a pattern whose shape is identical to, or similar to, that of the pattern on the surface or a heat-generating pattern is formed on its rear.
SOLUTION: In an electrostatic chuck, an electrode pattern 2, for the electrostatic chuck, which is conductive is formed on the surface of a support substrate 1 which is composed of an electric insulating ceramic, and a pattern 3 is formed on its rear. In this case, protective layers 4 are formed so as to respectively cover the patterns 2, 3 on the surface and the rear. In this manner, the pattern 2 for the electrostatic chuck is formed on the surface of the support substrate, and the pattern 3 whose shape is identical to, or similar to, that of the pattern on the surface is formed on the rear. Thereby, it is possible to prevent a warpage from being generated in its manufacture, its heating performance or its cooling performance which heats or cools a wafer is enhanced, and its stability can be enhanced in its heating operation or its cooling operation.



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(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号

特開平10－80168

(43)公開日　平成10年(1998) 3月24日

(51)Int.Cl.[6]　識別記号　庁内整理番号　ＦＩ　技術表示箇所

Ｈ０２Ｎ　13/00　Ｈ０２Ｎ　13/00　Ｄ

審査請求　未請求　請求項の数９　ＦＤ　（全 ６ 頁）

(21)出願番号　特願平8－250948

(22)出願日　平成８年(1996) ９月２日

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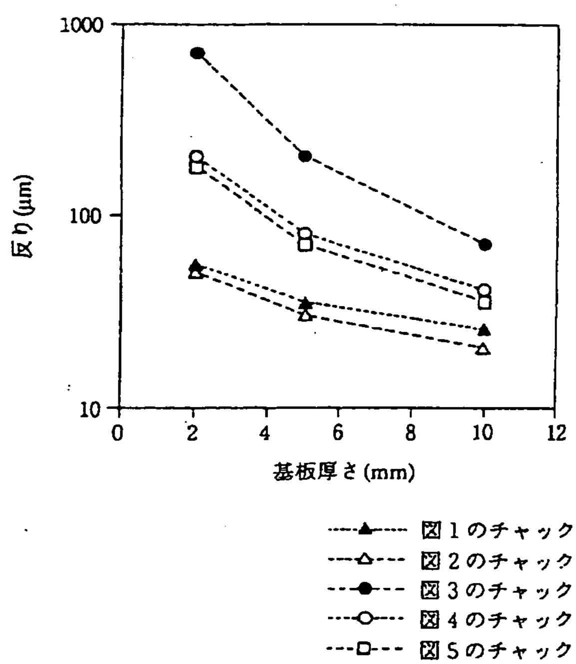
(54)【発明の名称】　静電チャック

(57)【要約】

【解決手段】　電気絶縁性セラミックスからなる支持基板の表面に静電チャック用電極パターンが接合されると共に、裏面に上記静電チャック用電極パターンと同一又は類似形状のパターンが接合されていることを特徴とする静電チャック。

【効果】　本発明によれば、半導体装置の基板となるウエハー等を静電気を利用して吸着する静電チャック、更には加熱機能を合わせ持つヒーター付静電チャックにおいて、その支持基板表面に静電チャックパターンが形成され、裏面には該パターンと同じ又は類似形状のパターン又は発熱パターンが形成されることにより、基板が薄くコンパクトでもその製造時の反りの発生が抑制され、またウエハーが加熱又は冷却される際に静電チャック及びヒーター付静電チャックの熱変形及び反り等が発生せずに静電吸着力が安定するという有利性が与えられ、低コストで性能の優れた静電チャック及びヒーター付静電チャックを供給することができる。



【特許請求の範囲】

【請求項１】　電気絶縁性セラミックスからなる支持基板の表面に静電チャック用電極パターンが接合されると共に、裏面に上記静電チャック用電極パターンと同一又は類似形状のパターンが接合されていることを特徴とする静電チャック。

【請求項２】　上記裏面のパターンの少なくとも一部が、電源に接続されることにより発熱部として構成される発熱パターンである請求項１記載の静電チャック。

【請求項３】　上記表面の静電チャック用電極パターンと裏面のパターンとが互いに実質的に同じ熱膨張係数を有する材料により形成された請求項１又は２記載の静電チャック。

【請求項４】　上記表面の静電チャック用電極パターンと裏面のパターンとが互いに実質的に同じ厚さを有する請求項１，２又は３記載の静電チャック。

【請求項５】　支持基板がＡｌＮ，ＢＮ，ＡｌＮとＢＮとの複合体，ＰＢＮ又はSiO_2にて形成された請求項１乃至４のいずれか１項記載の静電チャック。

【請求項６】　支持基板が化学気相蒸着法又は粉末焼結法により形成されると共に、表裏のパターンがそれぞれ化学気相蒸着法により形成された請求項１乃至５のいずれか１項記載の静電チャック。

【請求項７】　上記表裏のパターンをそれぞれ覆って支持基板と実質的に同じ熱膨張係数を有する保護層を形成した請求項１乃至６のいずれか１項記載の静電チャック。

【請求項８】　保護層がＡｌＮ，ＢＮ，ＡｌＮとＢＮとの複合体，ＰＢＮ又はSiO_2にて形成された請求項７記載の静電チャック。

【請求項９】　保護層が化学気相蒸着法により形成された請求項７又は８記載の静電チャック。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、半導体装置の基板となるウエハー等を静電気を利用して吸着する静電チャック及び加熱の機能を合わせ持つヒーター付静電チャックに関する。

【０００２】

【従来の技術及び発明が解決しようとする課題】近年の半導体素子の製造工程の中で、静電チャックは分子線エピタキシーやＣＶＤ、スパッタリング、エッチングなどでウエハーを静電吸着して支持するために用いられており、この静電チャックはプロセスの高温化に伴ってその材質は樹脂からセラミックスに移行している（特開昭５２－６７３５３号公報、特開昭５９－１２４１４０号公報参照）。また、最近ではセラミックスヒーターと静電チャックを合体した静電チャック付セラミックスヒーターも提案されている（特開平５－１０９８７６号公報、特開平５－１２９２１０号公報参照）。

【０００３】この場合、分子線エピタキシー、ＣＶＤ、スパッタリング等において、成膜を行うに際しては、ウエハーの温度が膜の性質、成膜速度に大きな影響があるため、ウエハーの均熱性の向上が求められている。また、ドライエッチングにおいては、ウエハーの温度が微細エッチング時のエッチング形状、選択比、分布等に大きな影響があるため、ウエハーを冷却するための冷却性能の向上が求められている。

【０００４】この静電チャックを製造する際、基板に静電チャック用電極パターンを接合し、更に絶縁層を設けるが、該基板及び絶縁層とパターン層の材質が相違し、特に熱膨張率が異なるために、製造時の熱履歴で反りが発生し、その反りが大きいと絶縁層の表面を研磨仕上げする時に一部のパターン層が表面に現れたり、もしくは現れないにしても絶縁層の絶縁耐圧が低下して不良品となってしまう。また、うまく研磨仕上げできたとしても、ウエハーを加熱及び冷却する際にこの熱膨張率差から起因した静電チャックの熱変形又は反りが発生し、その結果、静電チャックの加熱又は冷却時に吸着力が安定しないことが懸念されていた。これを解決する手段としては、基板を厚くすればよいが、熱容量が大きくなるため消費電力が増大し、さらには昇降温にも時間がかかり、またコスト的にも高くなってしまうため、なるべく薄くコンパクトなものが望まれていた。しかし、薄くすると上述の問題が発生してしまうため、基板を厚くせざるを得なかった。

【０００５】本発明は上記事情を改善するためになされたもので、基板が薄くコンパクトなものでも製造時の反りが小さく、しかも低温から高温まで安定した静電吸着力が得られる静電チャック及びヒーター付静電チャックを提供することを目的とする。

【０００６】

【課題を解決するための手段及び発明の実施の形態】本発明者は、上記目的を達成するため鋭意検討を行った結果、支持基板表面に静電チャックパターンを形成すると共に、裏面にこの静電チャックパターンと同一又は類似形状のパターンを形成すること、この場合、好ましくは両パターンを実質的に同じ厚さに形成することにより、基板とパターンの熱膨張率差による熱変形が表裏で相殺し、基板が薄くコンパクトなものでもその製造時の反りの発生が抑制され、またウエハーが加熱又は冷却される際に該静電チャック及び該ヒーター付静電チャックの熱変形及び反り等が発生せずに静電吸着力が安定することを知見し、本発明をなすに至った。

【０００７】即ち、本発明は、（１）電気絶縁性セラミックスからなる支持基板の表面に静電チャック用電極パターンが接合されると共に、裏面に上記静電チャック用電極パターンと同一又は類似形状のパターンが接合されていることを特徴とする静電チャック、（２）上記裏面のパターンの少なくとも一部が、電流が流されることに

より発熱部として構成される発熱パターンである上記（１）記載の静電チャック（ヒーター付静電チャック）、（３）上記表面の静電チャック用電極パターンと裏面のパターンとが互いに実質的に同じ熱膨張係数を有する材質にて形成され、更に好ましくは実質的に同じ厚さを有する上記（１）又は（２）記載の静電チャックを提供する。

【０００８】以下、本発明につき更に詳しく説明する。本発明の静電チャックは、図１及び図２に示すように、電気絶縁性セラミックスからなる支持基板１の表面に導電性を有する静電チャック用電極パターン２が形成されていると共に、裏面にもパターン３が形成されたものである。この場合、上記表裏のパターン２，３をそれぞれ覆って保護層４が形成される。

【０００９】本発明は、このような構成において、上記表裏のパターン２，３を図２，３に示すように互いに同一又は類似の形状としたものである。

【００１０】ここで、表裏のパターン２，３が同一又は類似とは、表裏基本形状（例えば同心円状、放射状、渦巻状、櫛状）が一致し、表裏パターン間隔、パターン線等のずれが２ｍｍ以下で、かつ表裏パターンを重ね合わせた時、重複していない部分の面積が重複している部分のそれの３０％以下であることが望ましい。このような点から、図１（ｂ），（ｃ）の表裏パターン２，３、図２（ｂ），（ｃ）の表裏パターン２，３は互いに類似であるが、図３は裏面にパターンが形成されていないので、これは勿論本発明の範囲外であり、また図４，５はそれぞれ表裏のパターン２，３が類似していないもので、本発明の範囲外である。

【００１１】この場合、上記表面側のパターン２は、図示したように、電源と接続されて電圧が印加されることにより、静電チャック機能が与えられるように公知のパターン方式に従って形成することができる。ここで、図示したものは双極形といわれているパターンであるが、単極形でも同様である。

【００１２】一方、裏面側のパターン３は、図１に示すように、複数のリング状パターンが同心状に形成されるなど、複数のパターン３ａが相互に独立して形成され、特に相互のパターン３ａとの電気的接続を考慮しないパターンとしてもよく、また、図２（ｃ）に示すように、電源に接続されて電圧を印加されることにより、発熱部を構成する発熱パターン３ｂ，３ｃとして形成することもでき、図２の静電チャックの場合は裏面側がヒーターとなるヒーター付静電チャックとして形成される。

【００１３】また、上記表裏のパターン２，３は互いにその厚さが実質的に同一であることが好ましい。この場合、これら表裏のパターン２，３は通常１０～５００μｍ、特に２０～２００μｍの厚さに形成されるが、表裏のパターン２，３が実質的に同じ厚さを有するとは、表裏のパターン２，３の厚さの差が１００μｍ以下のことであり、特に５０μｍ以下であることが好ましい。

【００１４】なお、上記基板１の厚さは適宜選定され、通常２～５０ｍｍ、特に１０～３０ｍｍに形成し得るが、本発明においては、基板１が薄くても反り等の問題が生じないので、５ｍｍ以下の厚さに形成し得る。

【００１５】また、上記表裏の保護層４の厚さは、それぞれ１０～２０００μｍ、特に５０～１０００μｍとすることが好ましく、しかもこの場合、表裏の保護層４，５は互いに実質的に同じ厚さで、即ち保護層４の厚さの差が３００μｍ以下、特に１００μｍ以下となるように形成することが好ましい。

【００１６】上記基板１の材質も電気絶縁性セラミックスの中から適宜選定することができ、従来の静電チャックの基板と同様の材質にて形成し得るが、特にＡｌＮ，ＢＮ，ＡｌＮとＢＮとの複合体，ＰＢＮ又はSiO_2にて形成することが好ましい。この場合、上記表裏の保護層４もＡｌＮ，ＢＮ，ＡｌＮとＢＮとの複合体，ＰＢＮ又はSiO_2にて形成することが好ましく、特に熱膨張係数を同じにするという点から、表裏の保護層４は互いに同じ材質にて形成することが好ましく、更にはこれら表裏の保護層４と基板１とは同じ材質とすることが好ましい。

【００１７】一方、上記基板１の表面に形成される静電チャック用電極パターン２は、導電性材料にて形成されるが、その材質としては公知のパターン形成材料を用いることができ、通常ＳｉＣ等の導電性セラミックス、カーボン、それにＷ，Ｐｔ，Ａｇ，Ｃｕ等を主とした金属にて形成することができる。

【００１８】また、基板１の裏面に形成されるパターン３は、好ましくは上記表面のパターン２と実質的に同じ熱膨張係数を有する材質にて形成することができ、具体的には上記と同様の導電性セラミックス、カーボン、金属にて形成することが好適であり、特に表面のパターンと同じ材質にて形成することが好ましい。なお、実質的に同じ熱膨張係数とは、表裏のパターン２，３の熱膨張係数の差が1×10^{-5}／℃以下、特に3×10^{-6}／℃以下であることが好ましい。

【００１９】このように支持基板表面に静電チャック用パターンを形成し、裏面に表面パターンと同一又は類似形状のパターンを形成し、好ましくは表裏のパターンを実質的に同じ熱膨張係数を有する材質、膜厚にて形成し、更には保護層を形成した場合には、これを支持基板と同じ材質又は同程度の特性の絶縁層とすることにより、製造時の反りの発生の防止、ウエハーを加熱又は冷却する加熱性能又は冷却性能の向上、加熱又は冷却時の安定性の向上を達成し得るものである。

【００２０】なお、支持基板、パターン、保護層の形成方法は特に制限されず、公知の種々の方法を採用し得るが、支持基板は化学気相蒸着法や粉砕焼結法により形成し、またパターン及び保護層はＣＶＤ法、ＰＶＤ法、真

空蒸着法等によって形成することが好ましい。この場合、これら方法は常法に従って行うことができる。

【００２１】

【実施例】以下、実施例と比較例を示し、本発明を具体的に説明するが、本発明は下記の実施例に制限されるものではない。

【００２２】〔実施例１，比較例１〕アンモニアと三塩化硼素とを１００Ｔｏｒｒ下に１８００℃で反応させて外径φ１００ｍｍ、厚さ２、５又は１０ｍｍの熱分解窒化硼素製支持基板を作製し、次いでメタンガスを２２００℃、５Ｔｏｒｒの条件下で熱分解してこれに厚さ１００μｍの熱分解グラファイト層を形成し、表面と裏面に図１～５のようなパターンをエンドミルを用いて加工した。更に、アンモニアと三塩化硼素とを１００Ｔｏｒｒ下に１８００℃で反応させて厚さ２００μｍの熱分解窒化硼素絶縁層を設けて、基板厚さ及びパターン形状の異なる１５種類の静電チャック及びヒーター付静電チャックを作製した。

【００２３】それぞれのパターン種の基板厚さと製造後の反りの関係を図６に示す。支持基板表面の静電チャックパターンが同心円状に形成され、裏面に該パターンと同形の同心円状のパターン又は発熱パターンを形成したもの（図１及び図２）は基板厚が２ｍｍと薄くても反りの少ない良好な静電チャック及びヒーター付静電チャックを作製することができることが認められた。

【００２４】〔実施例２，比較例２〕実施例１，比較例１で作製したもののうち基板厚２ｍｍで図１及び図２のものと基板厚１０ｍｍで図４のものの表面を研磨仕上げして、印加電圧を５００Ｖとしてそれぞれの静電吸着力の温度依存性を測定した。

【００２５】その結果、室温から４００℃まで基板厚１０ｍｍで図４のパターンのものと基板厚２ｍｍで図１，２のパターンのものは、すべての温度域において同程度の吸着力が得られた。このことより、基板厚を薄くしてもパターン形状の表裏の類似性を考慮して設計すれば、安定した静電吸着力が得られることが確認できた。

【００２６】〔実施例３，比較例３〕実施例１，比較例１と同様の方法で外径φ１００ｍｍ、厚さ２ｍｍの熱分解窒化硼素製支持基板を作製した後、厚さ２００μｍの熱分解グラファイト層を形成し、表面に静電チャックパターンを同心円状に、裏面には表面パターンと同径の同心円状の発熱パターンをエンドミルを用いて加工した。その後、静電チャックとなる導電層をサンドペーパー研磨して、２０μｍの厚さに仕上げた。次いで、熱分解窒化硼素絶縁層を設けて表裏導電層厚さの異なるヒーター付静電チャックを作製し、静電チャックとなる導電層を研磨していない、つまり導電層厚さが表裏等しいヒーター付静電チャックとの製造後の反りを比較した。

【００２７】その結果、表裏の導電層の厚さが同じ場合の反りが５０μｍであるのに対し、静電チャックとなる導電層が２０μｍの時の反りは３００μｍとなってしまった。この変形は、導電層と基板の熱膨張率が異なり、その差によって発生する熱応力と導電層の厚さが関与していると考えられ、従って、表裏導電層厚さが同じであることが好ましいことが認められた。

【００２８】〔実施例４，比較例４〕実施例１，比較例１と同様の方法で外径φ１００ｍｍ、厚さ２ｍｍの熱分解窒化硼素製支持基板を作製した後，表面には厚さ１００μｍの熱分解グラファイト層を形成し，裏面には厚さ１００μｍのＰｔ層を真空蒸着法により形成し、表面に静電チャックパターンを同心円状に、裏面には表面パターンと同径の同心円状の発熱パターンをエンドミルを用いて加工した。次いで、表裏導電層上に厚さ２００μｍの窒化硼素絶縁層を設けて表裏導電層の材質の異なるヒーター付静電チャックを作製し，表裏導電層とも厚さ１００μｍの熱分解グラファイト層でできたヒーター付静電チャックとの製造後の反りを比較した。

【００２９】その結果、後者の反りが５０μｍであるのに対し、前者は後者より大きくなり、反りは５００μｍとなってしまった。これは、表裏導電層材の熱膨張率差が関与していると考えられ、従って、表裏導電層の材質が同じであることが好ましいことが認められた。

【００３０】

【発明の効果】本発明によれば、半導体装置の基板となるウエハー等を静電気を利用して吸着する静電チャック、更には加熱機能を合わせ持つヒーター付静電チャックにおいて、その支持基板表面に静電チャックパターンが形成され、裏面には該パターンと同じ又は類似形状のパターン又は発熱パターンが形成されることにより、基板が薄くコンパクトでもその製造時の反りの発生が抑制され、またウエハーが加熱又は冷却される際に静電チャック及びヒーター付静電チャックの熱変形及び反り等が発生せずに静電吸着力が安定するという有利性が与えられ、低コストで性能の優れた静電チャック及びヒーター付静電チャックを供給することができる。

【図面の簡単な説明】

【図１】本発明の第１の実施例を示し、（ａ）は（ｂ），（ｃ）のＡ－Ａ線に沿った断面図、（ｂ）は平面図、（ｃ）は裏面図である。

【図２】本発明の第２の実施例を示し、（ａ）は（ｂ），（ｃ）のＡ－Ａ線に沿った断面図、（ｂ）は平面図、（ｃ）は裏面図である。

【図３】本発明の第１の比較例を示し、（ａ）は（ｂ），（ｃ）のＡ－Ａ線に沿った断面図，（ｂ）は平面図、（ｃ）は裏面図である。

【図４】本発明の第２の比較例を示し，（ａ）は（ｂ），（ｃ）のＡ－Ａ線に沿った断面図、（ｂ）は平面図、（ｃ）は裏面図である。

【図５】本発明の第３の比較例を示し、（ａ）は（ｂ），（ｃ）のＡ－Ａ線に沿った断面図、（ｂ）は平

面図、（ｃ）は裏面図である。

【図６】図１～５の実施例，比較例の静電チャックにおける基板厚さと反りの関係を示すグラフである。

【符号の説明】

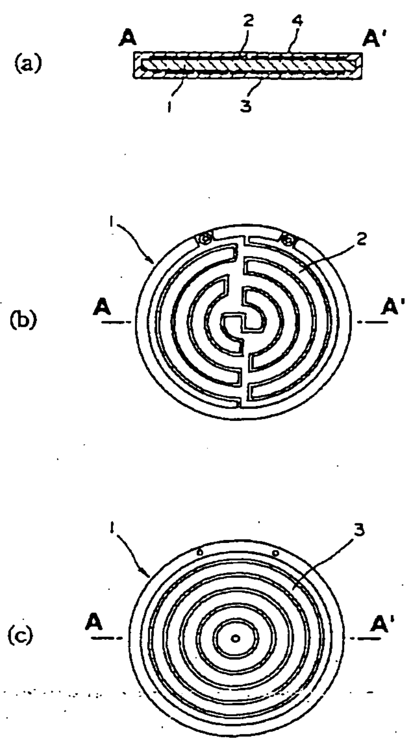
＊１　基板

２　静電チャック用電極パターン

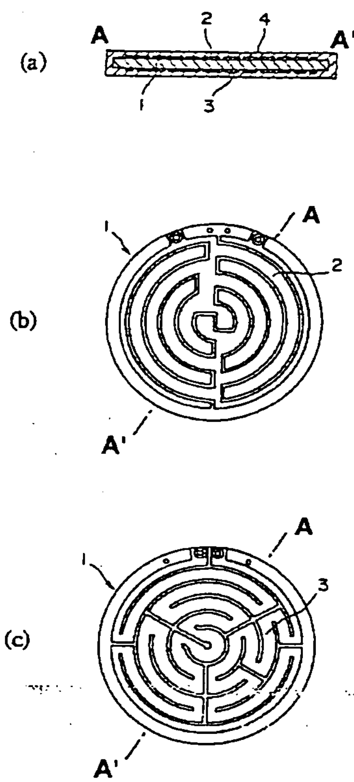
３　パターン

＊　４　保護層

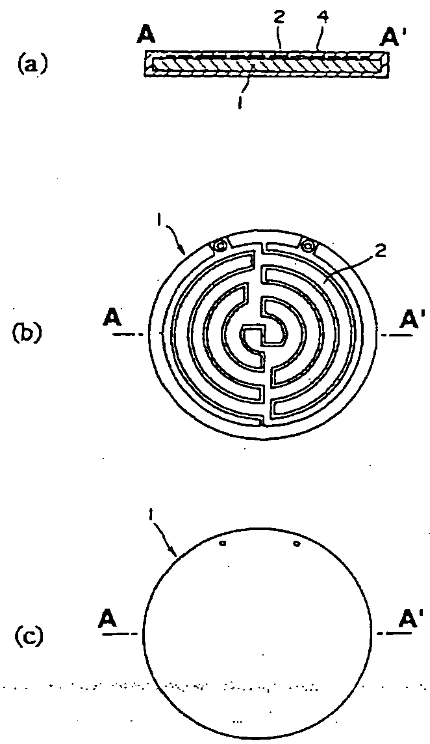
【図１】



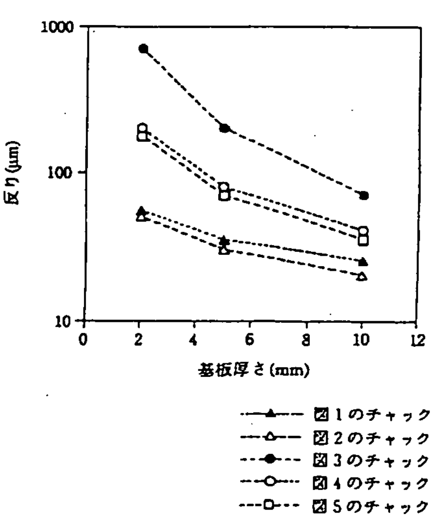
【図２】



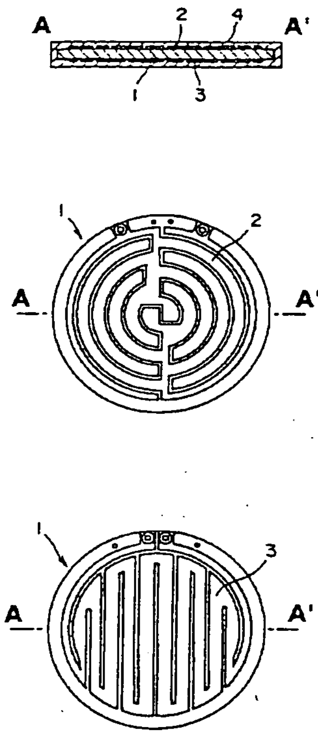
【図３】



【図６】

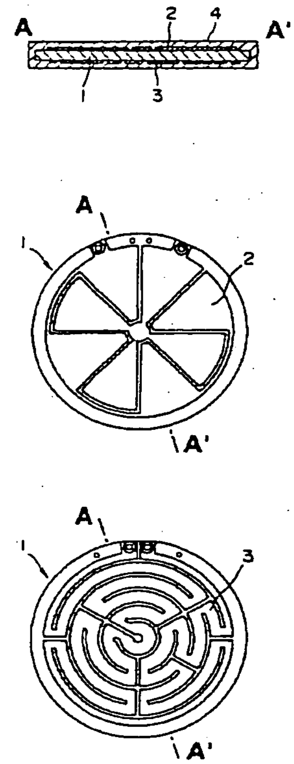


【図４】



(a) (b) (c)

【図５】



(a) (b) (c)

Japanese Patent Application Laid-Open No. 10-80168

[Title of the Invention]

ELECTROSTATIC CHUCK

[Abstract]

[Purpose] To provide an electrostatic chuck comprising electrode patterns for the electrostatic chuck bonded to the surface of a supporting substrate made of an insulating ceramic and patterns same as or similar to the electrode patterns for the above-mentioned electrostatic chuck bonded to the rear face.

[Effect] According to the present invention, with respect to an electrostatic chuck, more particularly an electrostatic chuck provided with a heater and thus having a heating function, for electrostatically attracting a wafer or the like to be a supporting substrate of a semiconductor device, electrostatic chuck patterns are formed on the surface of the supporting substrate and patterns or heating patterns same as or similar to the electrostatic chuck patterns are formed on the rear face, so that warp can be suppressed in the manufacturing process even if the substrate is thin and compact. Also, thermal deformation and warp of the electrostatic chuck or the electrostatic chuck provided with a heater can be prevented when a wafer is heated or cooled and thus the electrostatic attraction power can be stabilized. Consequently, an electrostatic chuck and an electrostatic chuck provided with a heater with excellent properties and capabilities can be provided at a low cost.

Claims

1. An electrostatic chuck comprising electrode patterns for the electrostatic chuck bonded to the surface of a supporting substrate made of an insulating ceramic and patterns same as or similar to the electrode patterns for the electrostatic chuck bonded to the rear face.

2. The electrostatic chuck according to claim 1, wherein at least a portion of the patterns in the rear face are connected to an electric power source so as to be a heating pattern composing as a heating part.

3. The electrostatic chuck according to claim 1 or claim 2, wherein the electrode patterns for the electrostatic chuck in the surface and the patterns in the rear face are made of materials having thermal expansion coefficients substantially same as each other.

4. The electrostatic chuck according to any of claims 1 to 3, wherein the electrode patterns for the electrostatic chuck in the surface and the patterns in the rear face have the substantially same thickness.

5. The electrostatic chuck according to any of claims 1 to 4, wherein the supporting substrate is made of AlN, BN, a compounded body of AlN and BN, PBN or SiO_2.

6. The electrostatic chuck according to any of claims 1 to 5, wherein the supporting substrate is formed by a chemical vapor deposition method or a powder sintering method and the patterns in the surface and the rear face are respectively formed by a chemical vapor deposition method.

7. The electrostatic chuck according to any of claims 1 to 6, wherein protection layers having substantially same thermal expansion coefficient as that of the supporting substrate are formed so as to cover the respective patterns in the surface and the rear face.

8. The electrostatic chuck according to claim 7, wherein the protection layers are made of AlN, BN, a compounded body of AlN and BN, PBN or SiO_2.

9. The electrostatic chuck according to claim 7 or claim 8, wherein the protection layers are made by a chemical vapor deposition method.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

The invention relates to an electrostatic chuck electrostatically attracting a wafer or the like to be a substrate of a semiconductor device and to an electrostatic chuck provided with a heater and thus having a heating function.

[0002]

[Prior Art and Problems to be Solved by the Invention]

An electrostatic chuck has been employed for electrostatically attracting and supporting a wafer in a molecular beam epitaxy, CVD, sputtering, or etching step or the like in the recent semiconductor device fabrication process and along with the tendency of higher temperature treatment in the fabrication process, a material of an electrostatic chuck has been shifted from resins to ceramics (reference to Japanese published unexamined Application Nos. 52-67353 and 59-124140) and recently, ceramic heaters provided with electrostatic chucks comprising ceramic heaters and electrostatic chucks united to each other have been proposed

(Japanese published unexamined Application Nos. 5 – 109876 and 5-129210).

[0003]

In this case, at the time of forming a film by molecular beam epitaxy, CVD, sputtering or the like, since the temperature of a wafer greatly affects the properties of the film and the film formation speed, it has been required to improve the heating evenness of the wafer. Further, in the case of drying etching, since the temperature of a wafer greatly affects the etching shape, selective ratio, distribution and the like of fine etching, it has been required to improve the cooling property for cooling the wafer.

[0004]

In manufacturing the electrostatic chuck, electrode patterns for the electrostatic chuck are connected to a substrate and an insulating layer is formed thereon, and since the materials of the substrate, the insulating layer, and the patterns differ one another and especially their thermal expansion coefficients differ one another, warp takes place owing to the thermal history during the fabrication process and if the warp is significant, at the time of finishing grinding of the surface of an insulating layer, a part of the pattern layer is exposed to the surface in some cases or even if it is not exposed, the dielectric strength of the insulating layer may be decreased to result in a defective product. Further, even if the finishing grinding is carried out well, thermal deformation or warp of the electrostatic chuck occurs at the time of heating or cooling a wafer attributed to the difference of the thermal expansion coefficients and the subsequent instable attracting force of the electrostatic chuck at the time of heating and cooling has been a

problem. One means for solving the problem is to use a thick substrate, however it results in increase of the heat capacity and increase of the electric power consumption and moreover, it takes longer to heat or cool the substrate and it results in cost up and accordingly, it is desirable to use a thin and compact substrate, if possible. However, if a thin substrate is used, the above-mentioned problems is generated and therefore, it is obliged to use a thick substrate.

[0005]

The invention is accomplished to solve the above-mentioned problems and aims to provide an electrostatic chuck or an electrostatic chuck provided with a heater whose warp in the manufacturing process is slight even if a thin and compact substrate is used and that is capable of providing electrostatic attracting force stable from a low temperature to a high temperature.

[0006]

[Means for Solving the Problems and Embodiments of the Invention]

Based on enthusiastic investigations carried out in order to achieve the above-mentioned aim, inventors of the invention have found that: thermal deformation owing to the difference of the thermal expansion coefficients of a substrate and patterns can be cancelled between the surface and the rear face; that warp of the substrate can be suppressed at the time of manufacturing the electrostatic chuck even if a thin and compact substrate is used; and that the electrostatically attracting force can be stabilized because of prevention of the thermal deformation and warp of the electrostatic chuck or the electrostatic chuck provided with a heater at the

time of heating or cooling a wafer, by forming electrostatic chuck patterns in the surface of the supporting substrate and patterns same as or similar to the electrostatic chuck patterns in the rear face and more preferably, forming both patterns in the same thickness and accordingly, inventors of the invention have accomplished the invention.

[0007]

That is, the invention provides: (1) an electrostatic chuck comprising electrode patterns for the electrostatic chuck bonded to the surface of a supporting substrate made of an insulating ceramic and patterns same as or similar to the electrode patterns for the electrostatic chuck bonded to the rear face; (2) an electrostatic chuck (an electrostatic chuck provided with a heater) as described in (1) of which at least a portion of the patterns in the rear face are formed to be a heating part by being communicated with electric current; and (3) an electrostatic chuck as described in (1) or (2) of which the electrode patterns for the electrostatic chuck in the surface and the patterns in the rear face are made of materials having thermal expansion coefficients substantially same as each other and further preferably, having the substantially same thickness.

[0008]

Hereinafter, the invention will be described in details. An electrostatic chuck of the invention, as shown in Fig. 1 and Fig. 2, comprises conductive electrode patterns 2 for the electrostatic chuck formed in the surface of a supporting substrate 1 made of an insulating ceramic and patterns 3 in the rear face. In this case, protection layers 4 are formed so as to cover the respective patterns 2 and 3 in the surface and the rear face.

[0009]

With such a constitution in the invention, the above-mentioned front and rear patterns 2 and 3 are made to be same as or similar to each other as shown in Fig. 2 and Fig. 3.

[0010]

That the front and rear patterns 2 and 3 are same as or similar to each other means the basic shapes in the front and the rear faces (e.g. concentric, radial, spiral, combteeth-shaped shapes) are coincident with each other and it is preferable that: the positional difference of the intervals of the front and rear patterns and the positional difference of the rims of the patterns are 2mm or smaller; and when the front and rear patterns are made to be stacked, the areas of portions where they are not overlapped is 30% or less of the areas of portions where they are overlapped. From such viewpoints, the front and rear patterns 2 and 3 shown in Fig. 1B and 1C and the front and rear patterns 2 and 3 shown in Fig. 2B and 2C are similar to each other, however patterns shown in Fig. 3 are out of the scope of the invention since they have no pattern in the rear face. Also, the front and rear patterns 2 and 3 shown in Fig. 4 and Fig. 5 respectively are out of the scope of the invention since the front and rear patterns 2 and 3 are not similar to each other.

[0011]

In this case, the above-mentioned patterns 2 in the surface side, as shown in Fig., can be formed by conventionally known patterning manner so as to be connected to an electric power source and have an electrostatic chuck function by applying voltage. The illustrated patterns are so-called

bipolar shape patterns and the foregoing constitution is same with respect to the patterns with unipolar shapes.

[0012]

On the other hand, as shown in Fig. 1, the patterns 3 in the rear face side may be composed of a plurality of respectively independent patterns 3a such as a plurality of concentric ring-like patterns or the like and particularly, the patterns 3 may be patterns 3a with no need of electrical connections to one another and as shown in Fig. 2C, the patterns 3 may be composed of heating patterns 3b and 3c composing heating parts by connecting the heating patterns to an electric power source and applying voltage to them and in the case of an electrostatic chuck shown in Fig. 2, the electrostatic chuck is made to be an electrostatic chuck provided with a heater formed in the rear side.

[0013]

The above-mentioned front and rear patterns 2 and 3 are preferable to have the substantially same thickness. In such a case, the front and rear patterns 2 and 3 are formed to have a thickness of generally 10 to 500 μm, preferably 20 to 200 μm. That the front and rear patterns 2 and 3 have the substantially same thickness means that the difference of the thickness between the front and rear patterns 2 and 3 is 100 μm or smaller, preferably 50 μm or smaller.

[0014]

The thickness of the above-mentioned substrate 1 is properly selected and it is generally 2 to 50 mm, preferably 10 to 30 mm and particularly in the invention, since problems such as warp are not caused

even if the substrate 1 is thin, the substrate can be made as thin as 5 mm or thinner.

[0015]

The thickness of the front and rear protection layers 4 is generally 10 to 2000 μm, preferably 50 to 1000 μm respectively. Moreover, it is preferable to form the front and rear protection layers 4 and 5 in such a manner that the front and rear protection layers have substantially same thickness and the difference of the thickness of the protection layers 4 is 300 μm or smaller, preferably 100 μm or smaller.

[0016]

A material for the above-mentioned substrate 1 may properly be selected among insulating ceramics and same materials as those conventionally used for electrostatic chucks can be used, however AlN, BN, a compounded body of AlN and BN, PBN, or SiO_2 is preferably used for the substrate. In this case, AlN, BN, a compounded body of AlN and BN, PBN, or SiO_2 is preferably used also for formation of the above-mentioned front and rear protection layers 4 and especially, from a viewpoint that thermal expansion coefficients should be same, the front and rear protection layers 4 are preferable to be made of the same material and further these front and rear protection layers 4 and the substrate 1 are preferable to be made of the same material.

[0017]

The electrode patterns 2 for the electrostatic chuck to be formed in the surface of the foregoing substrate 1 are made of a conductive material and any conventional material that is used as a pattern forming material

can be used and generally, conductive ceramics such as SiC or the like, carbon, as well as metals of mainly W, Pt, Ag, Cu or the like can be exemplified.

[0018]

The patterns 3 to be formed in the rear face of the substrate 1 may be made of a material having a thermal expansion coefficient substantially same as that of the foregoing front patterns 2 above-mentioned, and especially, as described above, a conductive ceramic, carbon, and metals are preferable to be used for forming the patterns and the material substantially same as that of the front patterns is especially preferable to be used. That the thermal expansion coefficient is substantially same means that the difference between the thermal expansion coefficients of the front and rear patterns 2 and 3 is generally 1×10^{-3}/°C or less, preferably 3×10^{-6}/°C or less.

[0019]

In such a manner, patterns for an electrostatic chuck are formed in the surface of a supporting substrate: the patterns same as or similar to the front patterns are formed in the rear face: preferably the front and rear patterns are made of materials having substantially same thermal expansion coefficient each other and are formed in the same film thickness: and in the case of further forming protection layers, insulating layers made of a material same as that of the supporting substrate or having properties approximately same as those of the supporting substrate are formed as the protection layers and thus occurrence of warp in the manufacturing process can be prevented and the heating or cooling capabilities for heating or

cooling a wafer can be improved and the stability at the time of heating and cooling can be improved.

[0020]

Incidentally, formation methods for the supporting substrate, the patterns, and the protection layers are not particularly limited and a variety of conventionally known methods can be employed, however it is preferable to form the supporting substrate by a chemical vapor deposition method or a crushing and sintering method and to form the patterns and the protection layers by a CVD method, a PVD method, a vacuum evaporation method. In such a case, these methods may be carried out according to conventionally known manners.

[0021]

[Examples]

Hereinafter, the invention will be described more particularly with reference to Examples and Comparative Examples, however the description is illustrative of the invention and is not to be construed as limiting the invention.

[0022]

[Example 1 and Comparative Example 1]

Supporting substrates with an outer diameter ϕ of 100 mm and a thickness of 2.5 or 10 mm and made of boron nitride by thermal decomposition were produced by reaction of ammonia and boron trichloride at 1800°C in 100 Torr or lower and then methane gas was thermally-decomposed under conditions of 2200°C and 5 Toor to form thermally-decomposed graphite layers thereon and the resulting substrates

were subjected to processing in the front and rear faces by an end mill to form patterns as shown in Fig. 1 to Fig. 5. Further, 200 μm-thick insulating layers of boron nitride produced by thermal decomposition were formed by reaction of ammonia and boron trichloride at 1800°C in 100 Torr to produce 15 types of electrostatic chucks and electrostatic chucks provided with heaters which were different in the substrate thickness and the pattern shapes.

[0023]

Correlations between the substrate thickness and the warp after production in the respective types of the patterns are shown in Fig. 6. Those having electrostatic chuck patterns formed concentrically in the surfaces of the supporting substrates and concentric patterns or heating patterns with the same shapes of the front patterns formed in the rear faces (Fig. 1 and Fig. 2) were found satisfactory to produce electrostatic chucks and electrostatic chucks comprising heaters with little warp even if the thickness of the substrates was as thin as 2 mm.

[0024]

[Example 2 and Comparative Example 2]

The surfaces of electrostatic chucks comprising substrates with 2 mm thickness and patterns as shown in Fig. 1 and Fig. 2 and electrostatic chucks comprising substrates with 10 mm thickness and patterns as shown in Fig. 4 produced in Example 1 and Comparative Example 1 were subjected to finishing grinding and the temperature dependency of the electrostatic attraction force of each electrostatic chuck was measured by applying voltage of 500 V.

[0025]

As a result, those comprising substrates with 10 mm thickness and patterns as shown in Fig. 4 and those comprising substrates with 2 mm thickness and patterns as shown in Fig. 1 and Fig. 2 were found capable of giving approximately constant attracting force in the entire temperature range from a room temperature to 400°C. Accordingly, it is confirmed that even if the thickness of a substrate is made thin, stable electrostatically attracting force can be obtained in the case an electrostatic chuck is designed in consideration of the similarity of the shapes of the front and rear patterns.

[0026]

[Example 3 and Comparative Example 3]

After supporting substrates with an outer diameter ϕ of 100 mm and a thickness of 2 mm and made of boron nitride by thermal decomposition were produced in the same manner as Example 1 and Comparative Example 1200 μm-thick graphite layers were formed by thermal decomposition and electrostatic chuck patterns were formed concentrically in the surfaces and heating patterns with the same diameters as those of the patterns in the surfaces were formed concentrically in the rear faces by using an end mill. After that, the conductive layers so as to compose the electrostatic chucks were ground by sand paper to finish them in a thickness of 20 μm. After that, insulating layers of boron nitride produced by thermal decomposition were formed to produce electrostatic chucks provided with heaters and comprising the front and rear conductive layers with different thickness and their warp after the production was compared with the warp of electrostatic

chucks provided with heaters and comprising the conductive layers without grinding, that is having the same thickness of the conductive layers in the front and rear faces.

[0027]

As a result, in the case the thickness of the conductive layers was same in the front and rear faces, the warp was 50 μm, meanwhile in the case the thickness of the conductive layers composing the electrostatic chucks was 20 μm, the warp was 300 μm. The deformation was supposedly attributed to the thermal stress and the difference of the thickness of the conductive layers caused by difference of the thermal expansion coefficients of the conductive layers and the substrate and consequently, it is confirmed that the thickness of the front and rear conductive layers is preferable to be same.

[0028]

[Example 4 and Comparative Example 4]

After supporting substrates with an outer diameter ϕ of 100 mm and a thickness of 2 mm and made of boron nitride by thermal decomposition were produced in the same manner as Example 1 and Comparative Example 1, 100 μm-thick graphite layers were formed by thermal decomposition in the surfaces and 100 μm-thick Pt layers were formed in the rear faces by vapor deposition method and electrostatic chuck patterns were formed concentrically in the surfaces and heating patterns with the same diameters as those of the patterns in the surfaces were formed concentrically in the rear faces by using an end mill. After that, 200 μm-thick insulating layers of boron nitride were formed on the front and rear conductive layers to

produce electrostatic chucks provided with heaters and comprising the front and rear conductive layers of the different materials and their warp after the production was compared with the warp of electrostatic chucks provided with heaters and comprising the front and rear conductive layers both of which were 100 μm graphite layers formed by thermal decomposition.

[0029]

As a result, the warp of the latter was 50 μm, and on the other hand, the warp of the former was 500 μm, considerably significant as compared with the warp of the latter. That is supposedly attributed to the difference of the thermal expansion coefficients of the materials of the front and rear conductive layers and accordingly, it is confirmed that the materials for the front and rear conductive layers are preferably same.

[0030]

[Effects of the Invention]

According to the invention, with respect to an electrostatic chuck, more particularly an electrostatic chuck provided with a heater and having a heating function, for electrostatically attracting a wafer or the like to be a supporting substrate of a semiconductor device, wherein electrostatic chuck patterns are formed on the surface of the supporting substrate and patterns or heating patterns same as or similar to the electrostatic chuck patterns are formed on the rear face, so that warp can be suppressed in the manufacturing process even if the substrate is thin and compact. Also, thermal deformation and warp of the electrostatic chuck or the electrostatic chuck provided with a heater can be prevented when a wafer is heated or cooled and thus the electrostatic attraction power can be stabilized.

Consequently, an electrostatic chuck and an electrostatic chuck provided with a heater with excellent properties and capabilities can be provided at a low cost.

[Brief Descriptions of the Drawings]

Fig. 1 shows a first Example of the invention. Fig. 1A is a cross-sectional view along the A-A line of Fig. 1B and 1C: Fig. 1B is a top view: and Fig. 1C is a back view.

Fig. 2 shows a second Example of the invention. Fig. 2A is a cross-sectional view along the A-A line of Fig. 2B and 2C: Fig. 2B is a top view: and Fig. 2C is a back view.

Fig. 3 shows a first comparative example. Fig. 3A is a cross-sectional view along the A-A line of Fig. 3B and 3C: Fig. 3B is a top view: and Fig. 3C is a back view.

Fig. 4 shows a second comparative example. Fig. 4A is a cross-sectional view along the A-A line of Fig. 4B and 4C: Fig. 4B is a top view: and Fig. 4C is a back view.

Fig. 5 shows a third comparative example. Fig. 5A is a cross-sectional view along the A-A line of Fig. 5B and 5C: Fig. 5B is a top view: and Fig. 5C is a back view.

Fig. 6 is a graph showing the correlations between the thickness of the substrates and the warp in electrostatic chucks of Examples and Comparative Examples shown in Fig. 1 to Fig. 5.

[Explanation of Symbols]

1 a substrate

2 electrode patterns of an electrostatic chuck

3 patterns

4 protection layers

Translation of the figure

[Fig. 6]

lateral axis: warp (μm)

longitudinal axis: substrate thickness (mm)

---▲--- the electrostatic chuck of Fig. 1

---△--- the electrostatic chuck of Fig. 2

---●--- the electrostatic chuck of Fig. 3

---○--- the electrostatic chuck of Fig. 4

---□--- the electrostatic chuck of Fig. 5